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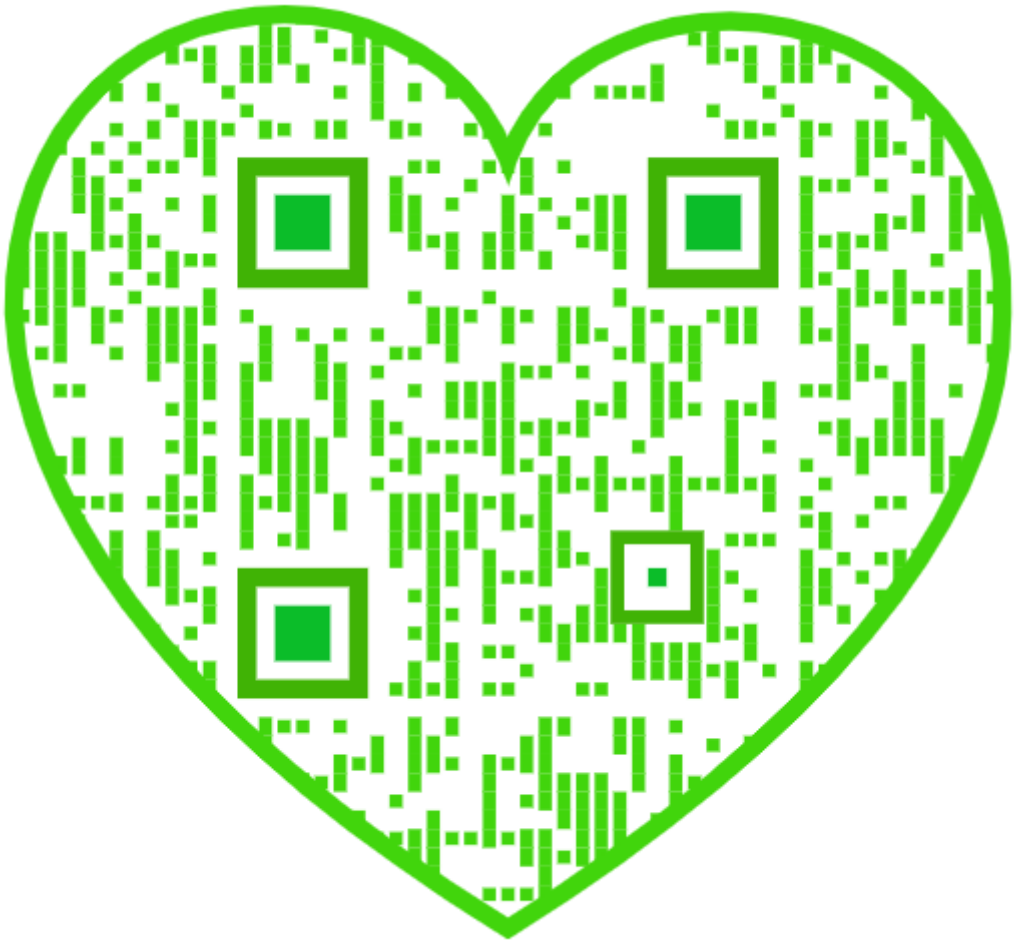

DEHYDRATION OF GRAPES

P. F. NICHOLS[1] AND A. W. CHRISTIE[2]

INTRODUCTION

The status of grape dehydration in recent years has undergone marked changes in California. Beginning as a means of salvaging raisins when sun drying conditions were unfavorable, it assumed new importance as a means of preserving wine grapes in the years of uncertainty immediatetly following the adoption of the Eighteenth Amendment. Other means being found for handling wine grapes to better advantage, interest in the dehydration of grapes declined until about 1925. In that year a new type of raisin, called the Golden Bleached Thompson, was first produced on a commercial scale as a competitor to the favorably known Smyrna raisin of commerce. Since that time this kind of raisin has assumed increasing importance in California, and this publication reports methods developed for its production and results of experiments in dehydrating this type of grape.

Grapes are one of the most important crops of California, the acreage exceeding that of any other fruit. Plantings being stimulated by high war-time prices, the acreage more than doubled from 1919 to 1927; but since that time both acreage and production have decreased slightly. At the peak of production not all the grapes were harvested, as shown in table 1. The annual farm value of the grape crop is about $50,000,000.

TABLE 1

TONS OF GRAPES PRODUCED IN CALIFORNIA*

	1924	1925	1926	1927	1928	1929
Raisins, fresh basis	679,000	800,000	1,086,000	1,139,000	1,044,000	780,000
Raisin grapes—marketed fresh	180,000	378,000	229,000	303,000	302,000	238,000
Raisin grapes—unharvested		38,000			60,000	
Table grapes	325,000	339,000	383,000	348,000	403,000	317,000
Table grapes—unharvested		100,000	15,000	142,000	75,000	
Wine grapes	350,000	395,000	414,000	473,000	464,000	416,000
Wine grapes—unharvested					18,000	
Total—all grapes	1,534,000	2,050,000	2,127,000	2,405,000	2,366,000	1,751,000

*From California Crop Report, 1928 and Summary of California Annual Fruit Crop Report, 1929; State Department of Agriculture.

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According to their principal uses, the many varieties of grapes grown in California may be classified conveniently into three groups: table grapes, wine grapes, and raisin grapes. Raisin grapes constitute about three-fifths of the crop and the others each about one-fifth. No market exists at present for dried table or wine grapes, but some raisin grapes are shipped fresh.

TABLE 2

APPROXIMATE TONNAGE OF RAISIN TYPES PRODUCED IN CALIFONIA, 1925–1929

Type	1925	1926	1927	1928	1929
Natural Muscat	31,000	58,000	52,000	41,000	28,000
Natural Thompson	133,000	145,000	151,000	162,000	134,000
Natural Sultana	12,000	11,000	12,000	12,000	8,000
Natural Currant	500	500	700	700	600
Golden Bleached Thompson	300	5,000	10,000	14,000	8,000
Sulfur Bleached Thompson	4,000	4,000	5,000	5,000	3,000
Soda Dipped Thompson	8,000	10,000	13,000	11,000	10,000
Oil Dipped Thompson	500	1,600	1,400	1,300	1,500
Oil Dipped Sultana	400	1,200	1,400	1,200	800
Total	200,000	272,000	285,000	261,000	215,000

Of the raisin grapes the only varieties, in the order of their importance, are the Sultanina or Thompson Seedless, the Muscat, the Sultana, and the Black Corinth or "currant" which is as yet produced on only a very small scale.[3] Most raisin grapes are dried in the "natural" condition, that is, without dipping and by sun drying. Of the varieties mentioned only the Thompson is extensively dried by any of the special methods involving dipping before drying (table 2). These methods produce special types which command a

[3] The nomenclature of the raisin grape varieties and the raisins made from them is rather confusing. According to Bioletti,(2)[4] Sultanina is the proper name for the grape known in California as the Thompson or Thompson's Seedless. It is from this variety that the raisins known by the rest of the world as Sultanas are made. It is the custom in California to refer to all raisins dried without previous dipping as Naturals; those first dipped in hot lye or soda solution, with or without a slight amount of olive oil, are called Sodas or Soda Dipped; and those dipped in soda or lye solutions containing considerable olive oil are called Oil Dipped. Thompsons dipped, sulfured and sun dried are called Sulfur Bleached; and those dipped, sulfured and dehydrated are called Golden Bleached. Muscat of Alexandria is the proper name for the grape known as Muscat in California, where the raisins are also known as Muscats. Natural sun dried raisins of this variety, particularly those from Australia and Spain, are known generally throughout the world as Malagas; and the Spanish or Australian lye dipped Muscats are known as Lexias or Valencias. The Sultana or Seedless Sultana of California produces the Inferior Sultana raisin of commerce.

[4] Superscript figures in parentheses refer to references at the end of this publication.

premium in price (table 3). The Muscat is grown almost entirely in sections of the state where sun drying conditions are most favorable,[3] and there is no premium in price for special kinds of Muscat raisins. The Sultana produces a raisin of lower commercial quality and is not particularly suited for the production of a special article.

TABLE 3

Cents Per Pound Paid to California Growers for Raisins by Types, 1925–1929

	Grade	1925	1926	1927	1928	1929
Natural Muscat	Standard	3¾	2½	2—2½	1¾	3
Natural Thompson	Standard	3¼	2¼	2—2½	1½	3¼
Natural Sultana	Standard	3	2½	2—2½	1½	3
Natural Currant	Standrad	5¼	3½—4	3½—4	6—7	5
Golden Bleached Thompson	Fancy	5½	6—6½	4¾—5¼	3—3½	4½
Sulfur Bleached Thompson	Fancy	6¼	5—6	3—4	1½—2½	4½
Soda Dipped Thompson	Standard	4¼	4¾—5¼	3—4	3—3½	4
Oil Dipped Thompson	Standard	5¼	4—5	3½—4	3—3½	4
Oil Dipped Sultana	Standard	3¾	4¼—4½	2½—3	2½—3	3½

Attempts to produce by dehydration a product closely resembling the natural raisin have met with little success. It has been found, however, that dehydration is of particular value in producing several of the special Thompson raisins that are in demand, particularly the Smyrna type so much preferred in the United Kingdom. Lye dipping, which is essential to efficient dehydration, is a normal step in the production of these special raisins. The bloom that is desired in natural raisins, but which is removed in the process of lye dipping, is of no value in these types.

Another occasion for the use of dehydration is for the drying of shipping grapes late in those seasons when the market for fresh grapes becomes unprofitable. Also this method may be used for completing drying begun in the sun but made difficult or impossible through the intervention of unfavorable weather. Chiefly, however, the use of dehydration is limited to the production of a lye dipped sulfured raisin known as the Golden Bleached Thompson.

EQUIPMENT FOR DEHYDRATING THOMPSON SEEDLESS GRAPES

The chief items necessary are dipping equipment, trays and trucks, usually sulfur houses, and the dehydrater itself.

Dipping Equipment.—Several types of dippers are used. All have a tank for the soda solution which is heated by steam coils or more

often by a fire pit. The grapes are immersed in the hot bath by one of the following devices:

1. Hand operated wire baskets of the merry-go-round type.
2. Mechanically or hand operated hinged wire baskets (fig. 1).
3. Power driven bucket or drag conveyors, run through the solution.

The dipper is not usually operated more than ten hours a day, handling in this time enough fruit to keep the dehydrater filled to capacity continuously through the 24-hour day.

Fig. 1.—Hinged basket type dipper, showing spraying and spreading apron.

Trays and Trucks.—Wooden trays supported and held apart in the stack by their own side cleats are universally used in the dehydration of grapes. Slat-bottomed trays are best and are used almost exclusively. For rapid drying the slats should not be much more than 1 inch wide, while for durability they should be not much less than ¾ inch wide, and well braced by cross cleats. The outside dimensions of the trays are usually 3 by 3, 3 by 4, 3 by 6, or 3 by 8 feet. The supporting side cleats of each tray should be at least 3½ inches high, permitting a free space of at least 3 inches for fruit and air between trays. More space is required for grapes than for prunes loaded at the same rate per square foot. The construction must be sturdy as well as permitting ready air circulation, since dehydrater trays are used about every other day and not just once or twice a season as is the case with sun drying trays. To provide for fruit in various stages

from dipping to unloading, the number of trays and trucks required will be at least twice that in a full charge of the dehydrater.

Sulfur and Sulfur Houses.—Any type or brand of sulfur is satisfactory provided it is free from arsenic and oil, is dry, and burns freely. To insure uniform sulfuring and avoid waste of the effective gas, sulfur dioxide, formed during the combustion of the sulfur, the sulfur house should be strongly constructed and tight with well-fitting doors. Some air besides that in the sulfur house is required to secure free burning of the sulfur, but one or two small openings having a combined area of not over 2 square inches will usually be sufficient. More openings will merely wast the gas, increase the sulfur requirement, and may interfere with the uniformity of sulfuring. Difficulty in burning the sulfur is sometimes experienced, but this may be overcome by using a forced draft provided by a fan and the necessary pipe connections 1 to 2 inches in diameter. In this case the gas may be recirculated by return pipes leading to the fan, and unavoidable leakage will usually provide sufficient fresh air. The sulfur houses are most commonly built of tongue-and-grooved lumber on a wooden frame and lined or covered with roofing paper, but they may be of concrete, brick, or hollow tile. They should be built to hold not more than two cars of fruit. Where the sulfur is burned in a pit in the floor, the house should be of sufficient length to prevent the trays of fruit from overhanging the pit, as the heat from the burning sulfur is likely to injure fruit and trays, while the trays interfere with the circulation of the fumes.

Dehydraters.—Nearly all the dehydraters in California are of the tunnel type. These differ with respect to the movement of the air and that of the fruit. Some dehydraters introduce the hottest air at the center of the drying tunnel, whence it divides and moves toward the opposite ends, giving up its heat to the fruit which moves only in one direction. This is sometimes called the combination system. Another system is the parallel current in which both air and fruit move in the same direction. A third system is the counter current, in which the direction of flow of air is always opposite to that of the movement of fruit. Each method has its practical and theoretical advantages. In practice the parallel current system has not been successful. The combination system and the counter current system seem about equally desirable, though the latter is more common.

There are about ten makes of successful dehydraters built commercially in California. Most of these have been greatly improved in efficiency and design as a result of the experience of the last ten

years. This Station has discontinued the practice of supplying plans and specifications for dehydraters and cannot in general recommend the building of dehydraters by growers unless they have the services of experienced and competent dehydrater builders. Unless they build according to the plans and under the guidance of successful dehydrater builders, it is probably best for growers to purchase commercially built plants. Most of the plants are patented in one or more details, and this Station cannot properly recommend any particular make any more than it can suggest the purchase of a particular make of tractor or automobile. Upon request a list of dehydrater manufacturers will be sent by the Fruit Products Laboratory, University of California.

Observation and experience do, however, make it possible to outline the general characteristics of dehydraters successful in grape drying. The low margin of profit in drying grapes requires that the operating and overhead costs be low. This end is accomplished by the use of an efficient dehydrater and one whose initial cost is low in proportion to its capacity. The investment per fresh ton drying capacity per 24 hours ranges from $350 to $500, generally decreasing up to a capacity of about 20 fresh tons per day. Larger tonnages are usually, though not necessarily, handled by additional drying units.

In most parts of California oil is the cheapest fuel. Direct heat, that is, mixing the combustion gases with the drying air, gives the highest fuel efficiency. Nevertheless, as compared with the direct radiation type of heating employing flues for the combustion gases, it results in little if any saving in fuel cost because of the higher grade of fuel required to secure a complete combustion and avoid smoke. Where cheap natural gas is available it may be substituted for oil. It permits direct heating without development of objectionable odors or smoke. However, natural gas is not available in many grape drying localities and artifically produced gas is far too expensive. Direct heating and high thermal efficiency are also possible with electricity but this is always too expensive, generally costing about ten times as much as oil under equally favorable conditions.

Because of the fact that more moisture has to be exaporated from a given weight of grapes than from the same weight of prunes, some dehydraters have not been so successful with this fruit as with prunes. The deficiency is usually a matter of inadequate heating capacity and of air velocity. Without going into details of calculation published elsewhere[8, 12, 6] these facts may be made more clear by comparing the requirements for prune drying[6] with those for a similar quantity of grapes in the same type of dehydrater (table 4).

TABLE 4

Comparison of Grape and Prune Dehydration Characteristics

	Prunes	Grapes
Capacity per 24 hours, fresh tons	10	10
Capacity per 24 hours, dry tons	4	2.5
Shrinkage in drier	2.5 to 1	4 to 1
Load per square foot, pounds	3.5	3.5
Drying time, hours	24	24
Spreading area in drier, square feet	5,714	5,714
Water evaporation, per hour, pounds	500	625
Over all thermal efficiency, per cent	45	45
Gallons fuel oil required per hour	8.6	10.8
Air volume required, cubic feet per minute	22,532	28,392
Air velocity between trays, feet per minute	750	990
Maximum temperature, hot end, degrees Fahrenheit	165	165
Maximum humidity, hot end, per cent	25	25
Maximum humidity, cool end, per cent	65	65

METHODS EMPLOYED IN DEHYDRATING THOMPSON SEEDLESS GRAPES

The steps involved in dehydrating Thompson seedless grapes are:

1. Selecting suitable fruit.
2. Dipping.
3. Sorting.
4. Traying.
5. Sulfuring.
6. Drying.
7. Unloading trays.

Choice of Fruit.—To secure the best yield and quality the grapes must be well matured. They should not be harvested before the juice reaches 23° Balling (per cent sugar). Also in this product the color, and particularly the uniformity of color, are of great importance. The best dried product is obtained when the grapes are creamy to golden yellow. Except when an attempt is made to make limited early deliveries for high prices on a bare market, any green color is to be avoided as far as possible. On the other hand, if grapes are left so long on the vine that shriveling or "raisining" of the berries becomes marked the dried fruit is likely to be too dark and to contain many brown to black berries which must be removed by expensive hand sorting. Long hauls tend to crush the fully ripe fruit. The supply should be so regulated that the grapes can be dried as soon as possible after arrival at the plant.

Dipping.—The purpose of dipping is to remove the dust and waxy bloom and to render the skin more permeable, thus hastening the drying process. Ideal dipping "checks" the entire skin with many short, shallow cracks. Dipping that is severe enough to produce long, deep cracks, is likely to peel some berries. This results in loss of juice and yield, sticky fruit, and sticky, troublesome trays. The more

advanced the maturity of the fruit, the more severe is the dip required to check the skin. For this reason it is important that all the fruit handled be as uniform in maturity as possible. A small amount of olive or other edible or tasteless oil in the dip is useful in preventing sticking of fruit to the trays. It also gives gloss to the dried product and makes it more free-running.

The severity of the dip is determined by the strength of the lye or soda solution, the temperature of the bath, and the time of immersion. To avoid a cooking effect the time of immersion should be short, about two to five seconds. The most efficient temperature is just below the boiling point (but not less than 200° F). The strength of the caustic solution should be adjusted to meet these conditions. If lye is used, 1 pound of lye per 10 to 20 gallons of water will usually give satisfactory results. To lessen the danger of over-dipping, many growers prefer to use larger amounts of a weaker caustic such as lye containing 50 per cent of sal soda, or a mixture of about 56 per cent sal soda and 44 per cent baking soda. Water must be added to replace that lost by evaporation and by adhering to the grapes. The acid juice of the grapes neutralizes some of the lye. To replace lye lost in this manner and by adhering to the grapes, caustic must be added occasionally. Between additions the dipping time may if necessary be varied to maintain satisfactory checking. For smooth operation it is better to make small, frequent additions of caustic. To stop the checking action quickly and to remove adhering lye, the grapes must be sprayed with fresh cold water immediately after leaving the dipper. (fig. 2).

Sorting.—In spite of efforts to have the fruit of uniform maturity and color some bunches of green berries or some containing many dark berries will be found. Since classification of the raisins is based chiefly on color and uniformity, the off-colored grapes should be removed in order not to disqualify the main bulk of the fruit from the best possible quality grade. This removal can be done most economically as the grapes are spread on the trays after spraying. If carefully done, this greatly reduces the cost of subsequent handling.

Traying.—Although a simple process, traying is important and should be carefully done. Uniform spreading of the fruit on trays is required to obtain uniform drying and thus avoid either expensive sorting and redrying or injurious over-drying. Spreading fruit to the full capacity of the trays is necessary to secure efficient operation of the dehydrater. These considerations are more important in dehydration than in sun drying. The load should range from 3 to 3.5

pounds of fresh fruit per square foot of tray area. To permit ready circulation of the drying blast of air large bunches of grapes should be divided by tearing them apart, clipping with shears, or cutting by passing the loaded trays under gangs of high speed rotary knives. The last method is rarely used and cannot be highly recommended because of the injury to berries and loss of juice.

Fig. 2.—Spraying, sorting, and spreading grapes on trays after dipping.

Sulfuring.—The general subject of sulfuring fruits has been discussed in some detail in another publication[13] of this Station to which the reader especially interested in the subject is referred. When sulfuring is done, as in the case of the Golden Bleached Thompsons with which we are principally concerned, the usual and successful commercial practice is to expose the dipped and trayed fruit on cars to the fumes of burning sulfur in a sulfur house.

To secure proper color and keeping quality and at the same time avoid restricting the salability of the raisins in foreign and domestic markets, some of which tolerate only limited contents of this preservative, it is desirable that the sulfur dioxide content of the dried fruit be between 200 and 1000 parts per million.[5] This condition will usually be met if from 2 to 4 pounds of sulfur are burned per ton of fruit, and if the fruit is exposed to the sulfur fumes for two to three hours.

[5] One thousand parts per million equals $\frac{1}{10}$ of 1 per cent.

Drying.—The fruit after dipping and sulfuring may be placed in the dehydrater immediately, or allowed to stand on the tray trucks from a few hours to several days, or it may be spread and partly dried in the sun (figs. 3 and 4). If the product desired is to be offered as Soda Dipped or as ordinary Sulfur Bleached raisins, for both of which the sun dried is the standard type, it is necessary to spread the fruit in the sun for one or two days to get the proper change in color before dehydrating. The proper color is reddish brown or creamy yellow, respectively. During this exposure a good deal of moisture is evaporated, leaving less to be removed in the dehydrater. This reduces the cost for fuel and power and by increasing the daily capacity it may distinctly reduce the overhead costs as well. In the production of Golden Bleached Thompsons exposure to the sun is not necessary. However, some operators believe it advantageous to allow the sulfured fruit to stand on the tray trucks for two or three days. This saves a great deal of labor as compared with the unstacking, spreading, and restacking of trays necessary for direct sun exposure, but the amount of moisture lost and the saving in fuel and power are much less and the possible saving in overhead expense is largely overbalanced by the necessity for greater investment in cars and trays.

The drying conditions in the dehydrater required for fruit partly sun or shade dried are very similar to those for fruit dried wholly in the dehydrater. The maximum safe finishing temperature appears to be the same. Since less water is to be evaporated the increase in the relative humidity of the air is less and a larger portion of the air may be recirculated. The drying time is, of course, dependent on the amount of water evaporated during the preliminary exposure, although the saving in drying time is not as great as the proportion of water removed. Exposure to the sun for one to two days usually makes a reduction of about one-fourth in the drying time. For safety and to provide for possible changes in handling methods, operators planning to adopt dehydration in combination with partial sun or shade drying should select dehydraters of sufficient capacity for handling all the fruit fresh.

The conditions to be maintained for efficient drying may be briefly defined. The *critical temperature* at which injury to the color and flavor of the fruit occurs at the finishing point of drying is about 165° to 170° F. Somewhat higher temperatures may be used safely when the grapes are still only partly dry and are less susceptible to injury. Recirculation of a large proportion of the air is always required for economy. The *relative humidity* of the air at the hottest

point of the tunnel should be maintained at about 25 per cent, in order to secure highest drying efficiency and best color in the product. The *air velocity* should be as high as is compatible with economy of power, preferably between 700 and 1000 lineal feet per minute between trays.

Fig. 3.—Spreading trays of sulfured grapes in the sun before dehydration.

Fig. 4.—Loading a truck of trays into the dehydrater.

Unloading Trays.—When the grapes reach the proper degree of dryness they should be removed promptly from the dehydrater to avoid unnecessary loss of weight and possible injury by over-drying. The unloading of trays is the next step (fig. 5) and this can be done to best advantage if certain precautions are taken. The grapes can be removed from the trays with the least labor in scraping and also with the least injury to fruit and wear on trays if unloading is done

as soon as the grapes have cooled but before the syrup has had time to harden. Unloading before or after this point should be avoided if possible. The sticking of raisins to the trays can be greatly reduced by soaking and scrubbing the trays in water after each passage through the dehydrater. This prevents the accumulation of thick and sticky syrup. Simple equipment can be used, consisting of a long tank for soaking and a power driven stiff fiber brush through which the trays can be pushed on the way to loading at the dipper. Also, as has been stated under the discussion of dipping, the use of a small amount of oil in the dip largely reduces sticking.

At the time of unloading trays the fruit should again be sorted. Any large bunches not sufficiently dry should be removed and re-dried if the quantity is considerable. Also it is very important in securing the highest classification of the raisins that any greenish or dark fruit which has been overlooked at the dipper or which has changed color in the dehydrater be removed at this time when separation is most easy. The Australian Sultana raisin has very definite standards for the number of dark berries permitted in the various grades, as follows[11]: none allowed in 5-Crown; 5 per cent allowed in 4-Crown; 15 in 3-Crown; 25 in 2-Crown; and 35 in 1-Crown, the lowest commercial grade.

No definite standards are as yet set in California, but the classification is similar.

Raisins should be stored in boxes rather than bins, for the fruit is subject to serious injury in the shoveling necessary when bins are used. The trays may be unloaded directly into boxes spread on the floor (fig. 6). A method which reduces spilling and soiling of the fruit is to unload the trays into a hopper under or through the bottom of which boxes may be pushed on a slide, or a conveyor installed to carry the fruit to boxes.

The proper stage of dryness of raisins is judged chiefly by the texture. As with other dried fruits, it is difficult to describe exactly the condition of sufficiently dried raisins. It is especially difficult with dehydrated fruit. All fruit is softened by heat, and while in a dehydrater or immediately after removal therefrom is softer and appears more moist than after it has cooled and sweated. On the other hand, dehydrated fruit hardens on cooling and when first cooled appears more dry than it really is. Only experience can give an operator good judgment in deciding on the finishing point. About all that can be said is that the fruit should be pliable but not mushy, the flesh well jelled, and it should not be possible to squeeze syrup from berries torn between the fingers.

Fig. 5.—Scraping raisins from the dehydrater trays.

Fig. 6.—Boxes spread on the floor to receive the raisins scraped from the trays.

It is generally conceded that the moisture content should not exceed 18 per cent. Raisins will not mold if the moisture content is below about 25 per cent, but they cannot be stemmed properly and sugaring of the fruit is greatly increased if the moisture content exceeds 18 per cent. The exact moisture content can be determined only by the vacuum oven method, which requires much time and expensive equipment. Several other methods, particularly a compression test[5] and a distillation test[14] require less time and only relatively simple equipment but their accuracy is such that they are useful only in getting relative moisture contents for factory control. It is not necessary for an experienced grower to make such tests. A dehydrater operator should never attempt to increase his yield or shorten his drying time by removing from his drier, grapes or other fruits before they are sufficiently dried. While no legal limit for moisture in raisins is established, good keeping quality and manufacturing practice demands that the moisture content be sufficiently low.

EFFECT OF MATURITY ON YIELD AND COMPOSITION

It is commonly known that the shrinkage or drying weight ratio of fresh to dry grapes decreases as the season advances and maturity proceeds. Whether this is due altogether to loss of moisture from the fruit on the vine, or to the deposition of more solid material in the grapes with resulting increase in the crop of dried material per acre could not be ascertained without careful study.[4] Bioletti[1] has reported experiments at Kearney Vineyard and at Davis indicating not only that the shrinkage decreases but also that the yield per acre increases on the average from 4.7 to 7.4 per cent for each Balling degree increase in the juice of the grapes at the time of picking. The increase is continuous at least until the juice reaches approximately 29° Balling. From these observations he calculated that "between the lowest degree of ripeness at which grapes are ever picked for raisin making, 18° Balling, and the highest at which it is usually possible, 28° Balling, there is an actual increase of weight of crop of about 60 per cent." Since not all normal costs increase in proportion to size of crop, profit may be much greater.

The experiments reported by Bioletti[1] also show that the quality of the raisins improves as the Balling degree of the grapes increases. The proportion of large raisins increased while the proportion of small berries decreased, and the average weight of the large raisins increased while that of the small raisins remained nearly constant.

TABLE 5

EFFECT OF MATURITY AND PRETREATMENT OF THOMPSON GRAPES UNON YIELD AND COMPOSITION OF DEHYDRATED RAISINS

Date harvested, 1926	Degrees Balling	Preparation	Drying time, hours	Basis of 15 per cent moisture						Total solids per 100 pounds grapes	
				Drying ratio	Pounds raisins per 100 pounds grapes	Average weight per berry, gram	Sugar, per cent	Non-sugar solids, per cent	Acid as tartaric, per cent	Based on raisins, pounds	Based on grapes, pounds
Aug. 22	18.3	Not dipped	19.5	4.58:1	21.8	.432	70.9	14.1	3.2	18.5	19.1
Aug. 22	18.3	Dipped	13.5	4.58:1	21.8	.432	72.6	12.4	2.9	18.5	19.1
Aug. 29	19.3	Not dipped	22.0	4.33:1	23.1	.432	71.1	13.9	2.8	19.6	19.5
Aug. 29	19.3	Dipped	14.0	4.37:1	22.9	.438	72.0	13.0	2.4	19.4	19.5
Sept. 5	19.3	Not dipped	26.0	4.31:1	23.2	.440	72.2	12.8	2.7	19.7	20.0
Sept. 5	19.3	Dipped	15.0	4.35:1	23.0	.440	71.5	13.5	2.5	19.6	20.0
Sept. 12	19.8	Not dipped	25.0	4.26:1	23.5	.457	74.2	10.8	2.5	20.0	20.2
Sept. 12	19.8	Dipped	17.0	4.38:1	22.8	.430	73.0	12.0	2.3	19.4	20.2
Sept. 19	19.7	Not dipped	27.5	4.29:1	23.3	.456	71.8	13.2	2.4	19.8	20.6
Sept. 19	19.7	Dipped	14.5	4.27:1	23.4	.468	71.8	13.2	2.1	19.9	20.6
Sept. 26	20.9	Not dipped	31.5	4.00:1	25.0	.504	72.4	12.6	2.1	21.2	21.4
Sept. 26	20.9	Dipped	19.0	3.98:1	25.1	.492	76.3	8.7	2.1	21.3	21.4
Oct. 3	20.8	Not dipped	32.8	4.06:1	24.6	.515	72.8	12.2	2.1	20.9	23.4
Oct. 3	20.8	Dipped	20.2	4.12:1	24.3	.495	70.9	14.1	2.0	20.6	23.4
Oct. 17	21.2	Not dipped	25.0	4.07:1	24.6	.498	73.3	11.7	2.0	20.9	21.4
Oct. 17	21.2	Dipped	19.7	4.05:1	24.7	.497	72.6	12.4	1.9	21.0	21.4

In 1926, in collaboration with H. E. Jacob,[6] a series of experiments was conducted in which representative Thompson grapes from a vineyard near Marysville were picked at weekly intervals. One portion of each lot was shipped by express to Berkeley. The fruits were carefully clipped from the stems leaving only the pedicels or capstems attached to the grapes. They were then thoroughly mixed and a sample taken for analysis. The remainder was divided into two samples, one of which was dipped in hot lye solution, and dried in a laboratory dehydrater at a constant temperature of 160° F. The other portion of the original lot was taken to Davis and sun-dried. The resulting data, mostly adjusted to a common moisture basis of 15 per cent for purposes of comparison, are given in tables 5 and 6. Similar data on dehydrated Muscats are given in table 7.

TABLE 6

EFFECT OF MATURITY OF THOMPSON GRAPES UPON YIELD AND COMPOSITION OF SUN-DRIED NATURAL RAISINS

Date harvested, 1926	Degrees, Balling	Basis of 15 per cent moisture					
		Drying ratio	Pounds raisins per 100 pounds grapes	Average weight per berry, gram	Sugar, per cent	Non-sugar, solids, per cent	Acid as tartaric, per cent
Aug. 22	18.4	4.38:1	22 5	.367	69.3	15.7	2.9
Aug. 29	18.9	5.32:1	18 8	.426	70.6	14.4	2.8
Sept. 5	19.4	4.54:1	22.0	.396	68 8	16.2	2.9
Sept. 12	19.7	4.41:1	22.7	.410	68 1	16.9	3.2
Sept. 19	20.8	4.27:1	23.4	.413	68.0	17.0	3.7
Sept. 26	21.8	4.23:1	23.6	.438	67.8	17.2	3.2

In the fresh Thompsons the sugar content increased with increase in Bal. degree of the juice, while moisture content and acid decreased. As shown in table 5, the sugar in the dehydrated raisins increased from about 71 to 73 per cent, a gain of 3 per cent of the original; acid decreased from 3 to 2 per cent, a reduction of 33 per cent; yield increased from 22 to 25 per cent, a gain of nearly 15 per cent; and weight per raisin made a similar increase. Among the sun-dried raisins the results were not so consistent but show interesting trends. While yield and weight per raisin increased in a similar manner to those of the dehydrated raisins, the percentage of sugar decreased and that of acid increased, just opposite to the figures for the dehydrated raisins.

[6] Associate in Viticulture.

TABLE 7

EFFECT OF MATURITY AND PRETREATMENT OF MUSCAT GRAPES UPON YIELD AND COMPOSITION OF DEHYDRATED RAISINS

Date harvested, 1926	Degrees Balling	Pretreatment	Drying time, hours	Basis of 15 per cent moisture						Total solids per 100 pounds grapes	
				Drying ratio	Pounds raisins per 100 pounds grapes	Average weight per berry, gram	Sugar, per cent	Non-sugar solids, per cent	Acid as tartaric, per cent	Based on raisins, pounds	Based on grapes, pounds
Aug. 29	23 1	Not dipped	28.0	3.53:1	28.3	1.136	68.3	16.7	2.73	24.1	24.6
Aug. 29	23.1	Dipped	18.5	3.55:1	28.2	1.056	68.5	16.5	2.71	23.9	24.6
Sept. 5	22.4	Not dipped	31.0	3.58:1	27.9	1.200	70.7	14.3	2.68	23.7	23.5
Sept. 5	22.4	Dipped	20.5	3.61:1	27.7	1.172	68.2	16.8	2.53	23.5	23.5
Sept. 12	25.0	Not dipped	29.5	3.30:1	30 3	1.275	72 1	12.9	2.49	25.7	26.4
Sept. 12	25.0	Dipped	21.5	3.31:1	30.2	1.324	68.9	16.1	2.26	25.6	26.4
Sept. 19	24.7	Not dipped	34.5	3.37:1	29.7	1.220	70.2	14.8	2.35	25.2	26.3
Sept. 19	24.7	Dipped	17.5	3.33:1	30.0	1 250	66.9	18.1	2.22	25.5	26.3
Sept. 26	25.4	Not dipped	35 2	3.23:1	31 0	1.307	71.3	13.7	2.17	26.3	28.2
Sept. 26	25.4	Dipped	19 8	3.23:1	31.0	1.223	67.7	17.3	2.00	26.3	28.2
Oct. 3	27.0	Not dipped	38.0	3.13:1	33.0	1 374	69.3	15.7	1.84	28.0	27.9
Oct. 3	27.0	Dipped	26.0	3.06:1	32.7	1 353	68 0	17.0	1.87	27.8	27.9

The figures given on Muscats in table 7 show that the sugar content of the raisins made no consistent increase with Balling degree of the juice. However, the yield, acid, and weight per raisin showed trends in the same direction as those of the Thompsons. Yield increased from about 28 to 33 per cent, a gain of 18 per cent over the original; acid decreased from 2.7 to 1.9 per cent, a loss of 30 per cent; and weight per raisin increased from 1.1 to nearly 1.4 grams, a gain of 24 per cent.

These results generally confirmed the conclusions drawn by Bioletti[1] and his associates from experiments performed at Kearney Park and Davis in 1913 and 1914. The improvement in quality of both Thompsons and Muscats as indicated by relative weight per berry was similar to that reported by Bioletti for Muscats. The increases in yield were less than those reported by him for Muscats and Thompsons at Kearney, but similar to those for Muscats at Davis. The differences may be the result of more favorable climate, soil, or crop conditions for these varieties at Kearney.

EFFECTS OF DIPPING

That dipping shortens the time required for dehydration is clear from the figures in tables 5 and 7. The actual hours of drying reported in these experiments are not representative of commercial operations, since drying is more rapid in a laboratory dehydrater at constant temperature. However, they serve to show the relative differences in drying rate.

Effect of Dipping upon Yield.—In most dehydration experiments as shown in tables 5 and 7, the yield of dipped raisins was less than that of raisins dehydrated without dipping. As the sugar content of the dipped dehydrated raisins was not consistently lower than that of those dehydrated without dipping, the lower yields apparently resulted from loss of syrup in preparation and drying rather than from washing out of suger in the dipping vat.

On the other hand in a series of experiments in which sun drying was used in studying the effects of dipping, the yields of dipped raisins were consistently higher than those of the undipped or natural raisins. In these experiments the portions dried in each instance were all of the same original lot, mixed and separated after clipping each grape and its cap stem from the bunch stems. The results are given in table 8. The lower yields of undipped sun dried raisins appeared to result from respiration losses during the slow drying, or through fermentation. The latter loss assumed importance during

TABLE 8

EFECT OF PRETREATMENT AND DRYING METHOD UPON YIELD AND COMPOSITION OF THOMPSON RAISINS

Locality and year	Pretreatment	Drying	Basis of 15 per cent moisture					Solids per 100 pounds of fresh grapes			
			Drying ratio	Pounds raisins per 100 pounds grapes	Sugar, per cent	Non-sugar solids, per cent	Acid as tartaric, per cent	Sugar, pounds	Non-sugar solids, pounds	Acid as tartaric, pounds	Total solids, pounds
Live Oak, 1925	None	Sun dried	4.33:1	23.1	72.3	12.7	.....	16.7	2.9	.....	19.6
	None	Dehydrated	4.02:1	24.9	73.0	12.0	.....	18.2	3.0	.....	21.2
	Dipped	Sun dried	4.17:1	24.0	72.8	12.2	.....	17.5	2.9	.....	20.4
	Dipped	Dehydrated	4.18:1	23.9	72.4	12.6	.....	17.3	3.0	.....	20.3
	Dipped and sulfured	Sun dried	4.18:1	23.9	72.4	12.6	.....	17.3	3.0	.....	20.3
	Dipped and sulfured	Dehydrated	4.17:1	24.0	71.7	13.3	.....	17.2	3.2	.....	20.4
	Fresh grapes	None	3.98:1	25.1	73.1	11.9	.....	18.3	3.0	.....	21.3
Live Oak, 1926	None	Sun dried	6.90:1	14.5	69.0	16.0	2.1	10.0	2.3	.30	12.3
	None	Dehydrated	3.76:1	26.6	72.6	12.4	2.0	19.3	3.3	.54	22.6
	Dipped	Sun dried	4.59:1	21.8	67.5	17.5	2.2	14.7	3.8	.48	18.5
	Dipped	Dehydrated	3.82:1	26.2	68.6	16.4	1.9	18.0	4.3	.51	22.3
	Fresh grapes	None	3.66:1	27.3	71.1	13.9	2.0	19.4	3.8	.56	23.2
Modesto, 1926	None	Sun dried	4.41:1	22.7	72.7	12.3	1.7	16.5	2.8	.38	19.3
	None	Dehydrated	3.08:1	32.5	71.4	13.6	1.8	23.2	4.4	.60	27.6
	Dipped	Sun dried	3.16:1	31.6	72.0	13.0	1.6	22.8	4.1	.52	26.9
	Dipped	Dehydrated	3.11:1	32.2	72.6	12.4	1.8	23.4	4.0	.58	27.4
	Fresh grapes	None	3.02:1	33.1	72.0	13.0	1.8	23.8	4.3	.59	28.1

the experiments at Modesto in 1926 and especially in the experiments at Live Oak in that year. In the course of the experiments, heavy rains occurred, followed by unfavorable drying weather, as sometimes happens in commercial operations. As a result material losses in yield of undipped sun dried raisins occurred at Modesto, though without serious apparent damage to the fruit. At Live Oak a distinct loss in yield occurred even in the dipped sun dried raisins, while in those sun dried, but not dipped, the loss in yield was even more serious than at Modesto and the sample was obviously fermented. The loss during dehydration was never serious, though most complete conservation of the solids in the fresh grapes was accomplished when they were dehydrated without dipping. In these experiments the dehydrated grapes were dried in commercial plants.

The Effects of Oil in the Dip.—The increased production of Golden Bleached Thompsons in recent years has in part been responsible for new interest in the use of oil in the dip. For some time olive oil has been used in a cold sodium bicarbonatae dip,[7] and also in a hot dip in making the so-called Oil Dipped raisins. Small amounts of oil have been used by some growers in making the more common Soda Dipped type. In addition to the gloss secured and the protection from rain spotting in sun drying gained by the use of oil, it has been found that the fruit is more free running and the usual difficulty in stemming dipped raisins is reduced. The oil dipped fruit keeps better in storage because it has less tendency to sugar. It has also been observed that fruit with a film of oil is less subject to attack by storage insects. Olive oil, however, tends to become rancid in time. In the attempt to eliminate this difficulty a neutral, inert mineral oil was tried but in spite of the admittedly harmless nature of this oil, its use on packed fruit has been prohibited by the Federal Food, Drug, and Insecticide Administration on the grounds that it is a foreign and also a medicinal substance. The allowable substitute, raisin seed oil, is in no way superior to olive oil so far as rancidity is concerned.

A series of experiments was undertaken in 1928 to compare the effects of several oils and oily substances in the lye dip. Among the substances selected and the reasons for their selection were:

1. Crystal oil—a neutral, water white, inert mineral oil incapable of rancidification.
2. Olive oil—commonly used, subject to rancidification.
3. Hydrogenated coconut oil—refined, presumed to have only slight tendency to rancidify.
4. Glycerin—pure, soluble in water, incapable of rancidification.

These oils were added to the dipping vat in sufficient quantity to form a film about 1/8 inch thick on the surface, except for the glycerin, which was used in two strengths, approximately 1½ and 4 per cent. Grapes from the regular stock at the plant where the experiments were run[7] were subjected to the boiling lye dip in the usual manner, both without the addition of oily substances, for control, and also with each substance. A number of trays were treated with each dip and these were dried by several different methods, the results of which are described later.

TABLE 9

Effect of Special Dipping upon Characteristics of Thompson Raisins

Dip	Rank after storage			
	Color	Freedom from sugaring	Freedom from infestation	General character
Lye only	Second	Third	Third	Third
Lye and mineral oil	Sixth	First	First	Second
Lye and olive oil	First	Second	Fourth	First
Lye and coconut oil	Fourth	Sixth	Sixth	Sixth
Lye and 1½ per cent glycerin	Fifth	Fourth	Fifth	Fifth
Lye and 4 per cent glycerin	Third	Fifth	Second	Fourth

All the lots given a special dip had more gloss than those given the regular lye dip. Those treated with mineral oil, olive oil, and coconut oil had slight but perceptible oiliness, particularly the last two. Those treated with glycerin were slightly sticky.

Taken as a whole, without regard to method of drying, the general opinion of those who examined the fruit soon after drying was that the dip containing mineral oil gave fruit of the best appearance, free running, having a gloss and yet free from stickiness.

The fruit was placed in storage in the laboratory in paper cartons with tuck ends, exposed to insect attack. At intervals it was examined and its condition recorded. The results are summarized in table 9. From this it will be seen that, judged without regard to the method of drying, the use of olive oil gave the only improvement in color over lye alone. Mineral oil and olive oil, in the order given, gave added protection against sugaring in storage. Mineral oil and 4 per cent glycerin gave increased protection against insect attack, but neither gave complete protection. The chief insect attacking the sample was the saw-toothed grain beetle. All the samples were visited and more

[7] By the courtesy of D. P. Boothe, Modesto, whose cooperation is gratefully acknowledged.

or less soiled by these insects and only one sample, which had been dipped in mineral oil, was not apparently eaten by the insects. Considering all these characters as of equal value, olive oil and mineral oil appeared to serve a useful purpose, but coconut oil and glycerine could not be considered of value on the basis of these experiments.

EFFECTS OF DRYING METHODS ON QUALITY

In the experiments involving the use of various oily substances in the dip a portion of each lot of fruit dipped was treated in the following manner:

1. Dehydrated immediately.
2. Stacked 1 day, then dehydrated.
3. Spread in the sun 1 day, then dehydrated.
4. Sulfured 2 hours, then dehydrated.
5. Sulfured 2 hours, stacked 1 day, then dehydrated.
6. Sulfured 2 hours, spread in sun 1 day, then dehydrated.
7. Sulfured 2 hours, spread in sun 5 days, finished in stack.
8. Sulfured 2 hours, spread in sun 2 days, finished in stack.

A notable effect was that several of the samples not sulfured appeared light enough in color to be considered under the usual classification of sulfured California raisins, or at least many of the berries were of this character. Chief among these samples were the ones dehydrated immediately after dipping in lye with glycerin or lye with coconut oil, and the sample dipped in lye with olive oil followed by standing in the stack for one day before dehydration. None of these were sufficiently light or uniform in color to be graded as first class golden bleach or sulfured fruit, and they were generally of a reddish yellow color, suggesting the Smyrna type so popular in the United Kingdom. The color did not change noticeably on prolonged storage. These results seem to merit some consideration, for if means could be found to secure greater uniformity of color it would be possible to produce a light colored unsulfured raisin for which a demand exists at a premium in price.

Among unsulfured lots and without regard to the dip used, the fruit dehydrated after one day of exposure to the sun gave best general results, considering color, freedom from sugaring, and freedom from insect infestation as of equal importance. Next came the fruit stacked one day before dehydration. The least desirable from the general point of view was that dehydrated immediately. However, the fruit dehydrated immediately was least susceptible to insect infestation.

Among sulfured lots without regard to the dip used the relative standing from all points of view was as follows:

First, that spread in the sun 1 day, then dehydrated.
Second, that dehydrated immediately.
Third, that stacked 1 day, then dehydrated.
Fourth, that spread in the sun 2 days, finished in the stack.
Fifth, that spread in the sun 5 days, finished in the stock.

From the standpoint of color alone the lots had the following order of merit:

First, that spread in the sun 1 day, then dehydrated.
Second, that stacked 1 day, then dehydrated.
Third, that dehydrated immediately after sulfuring.
Fourth, that spread in the sun 2 days, finished in the stack.
Fifth, that spread in the sun 5 days, finished in the stack.

Sulfuring did not reduce insect infestation, and generally throughout the series the degree of infestation seemed to increase with delay in drying, indicating that infestation may be in part due to exposure before drying. Dehydrated samples were usually less susceptible than those not dehydrated.

These classifications can be considered only as general indications, for the differences in the average scores was often slight, and there was some disagreement among those scoring the fruit. Moreover, a complete picture is not given by comparing dips without regard to drying method, or by comparing drying methods without regard to dip. If dips are compared by single methods of drying, the results are not all consistent, and the same may be said of comparing methods of drying by single dips. In other words, certain dips are apparently best suited for certain methods of drying but not for others. The extent of the work and scoring done does not, however, permit more definite recommendations to be made with respect to each.

Effect of Humidity upon Drying Time and Quality.—In 1926 a series of experiments was undertaken in which the effect of humidity in the dehydrater upon drying time and quality was studied. In these experiments the grapes used were from Livingston, with an average initial moisture content of 73 per cent, sugar content of 23.6 per cent and juice Balling test of 26.5°. The grapes were prepared by clipping from the bunches, mixing, dipping in boiling ¼ per cent lye solution, rinsing in fresh, cold water, and loading on trays at a uniform rate of about 3 pounds per square foot. Four trays one foot square were used in each experiment and they were dried in a laboratory dehy-

drater under accurate control. To simulate commercial conditions in part the temperature in each experiment was set at 135° F at the beginning and was raised to a final temperature of 165° F by hourly increases in proportion to the loss in weight. The relative humidity was adjusted in a similar manner to final values of 40, 25, and 15 per cent, respectively. The air velocity was constant throughout all three experiments at 500 feet per minute. The conditions maintained and the drying curves are shown in figure 7. The composition of the raisins adjusted to a 15 per cent moisture basis, is given in table 10.

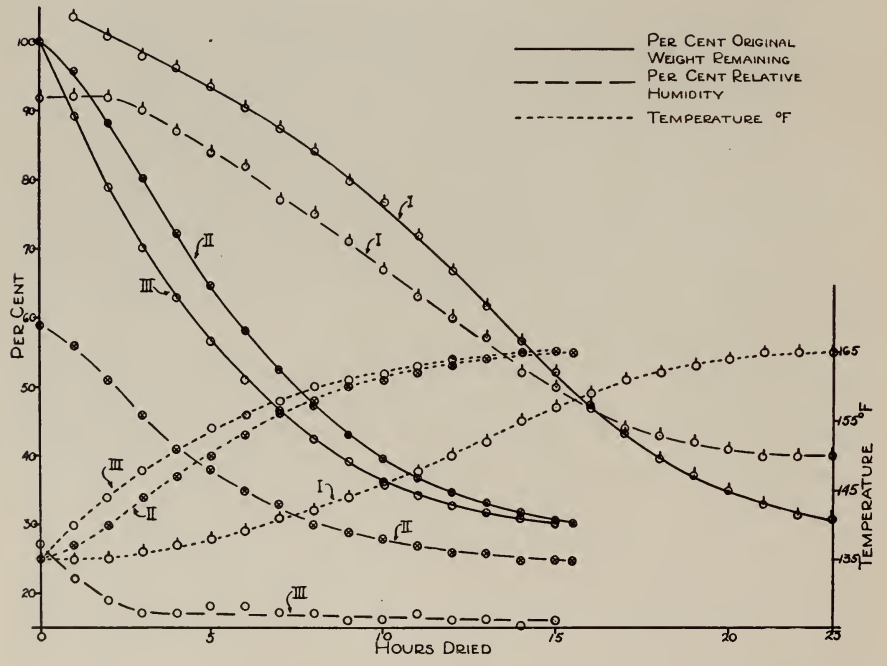

Fig. 7.—The effect of temperature and relative humidity on the dehydration time of Thompson seedless raisins.

I, high humidity; II, medium humidity; III, low humidity.

As figure 7 shows, when the final humidity was 40 per cent the drying rate was considerably retarded, but was very nearly as fast when the final humidity was 25 per cent as when it was 15. As shown in table 10, there were no significant or consistent differences in composition resulting from differences in humidity. That the yield in each case was slightly lower than the theoretical is probably due to losses of soluble solids in dipping and rinsing and to losses of juice that occurred particularly at the highest humidities.

From these experiments it may be concluded that:

1. A moderate humidity not exceeding 25 per cent at a finishing temperature of 165° F is the most desirable for the dehydration of dipped unsulfured seedless grapes because it gives rapid, efficient dehydration and a product most closely resembling normal sun dried soda dipped raisins of good commercial quality.

2. A very low humidity does not materially reduce drying time and would reduce fuel efficiency through reduction of recirculation; the product is not so uniform in color as when moderate humidity is used.

3. High humidity by greatly increasing drying time would decrease capacity and increase costs; the product is undesirably sticky and dark in color.

TABLE 10

Effect of Humidity on the Drying Time, Yield, and Composition of Dehydrated Thompson Raisins

Experiment	Final relative humidity, per cent	Drying time, hours	Basis of 15 per cent moisture				Condition and grade
			Drying ratio	Pounds raisins per 100 pounds grapes	Sugar, per cent	Acid as tartaric, per cent	
I	40	23	3.26:1	30.7	74.32	1.78	Uniform dark brown color. Very sticky. Graded as Standard Sodas.
II	25	15.5	3.18:1	31.4	73.86	1.76	Uniform light brown color. Slightly sticky. Graded as Extra Standard Sodas.
III	15	15.0	3.23:1	31.0	74.12	1.75	Lightest in color but not uniform. Not sticky. Graded as Extra Standard Sodas.
Fresh grapes	.....	.....	3.14:1	31.8	74.30	1.61	

COST OF DEHYDRATING GRAPES

Improvement in the construction and operation of dehydraters in California up to 1924 or 1925 was so rapid that cost figures given in prior publications of this station,[9, 10] and which apply to other types of grapes than Thompson, can hardly be said to apply at the present time. More recent observations are given in table 11. At an average total cost of $9.51 and an average shrinkage ratio of 3.75 to 1 this amounts to $35.66 per dry ton of raisins. The operating cost alone amounts to $5.06 per fresh ton or $18.98 per dry ton on the average.

TABLE 11

COST OF DRYING THOMPSON GRAPES ENTIRELY IN A DEHYDRATER

Item	Unit, average	Cost per fresh ton		
		Maximum	Average	Minimum
Labor	6.81 man-hours	$5.58	$3.11	$1.73
Fuel	23.6 gallons oil	1.27	1.10	.92
Power and light	27.2 kw-hr.	1.38	.56	.22
Lye	2.4 pounds	.29	.14	.03
Sulfur	3.6 pounds	.25	.15	.02
Total operating cost*		$ 8.54	$5.06	$3.17
Total overhead cost**		10.08	4.45	1.32
Total cost		$18.62	$9.51	$5.13

*Observations made on 4 plants. **Observations made on 3 plants.

TABLE 12

COST OF DRYING THOMPSON GRAPES PARTLY IN THE SUN AND PARTLY IN A DEHYDRATER

Item	Unit, average	Cost per fresh ton		
		Maximum	Average	Minimum
Labor	10.2 man-hours	$6.20	$3.88	$1.96
Fuel	12.7 gallons oil	1.16	.55	.22
Power and light	24.3 kw-hr.	.85	.48	.30
Lye	1.8 pounds	.18	.13	.05
Sulfur	2.7 pounds	.11	.11	.11
Total operating costs*		$8.39	$5.08	$2.69
Total overhead costs**		3.62	3.48	3.35
Total cost		$11.74	$8.56	$6.31

*Observations made on 3 plants. **Observations made on 2 plants, dehydrater only.

Costs involved when the grapes were partly dried in the sun before being placed in the dehydrater are given in table 12. These costs include both dry yard and dehydrater operation, but no overhead charges for the dry yard. It will be seen that the operating costs are almost exactly the same as when dehydration alone is employed. The extra labor cost involved in spreading the fruit in the yard and again loading it on the dehydrater trucks is almost exactly balanced by the saving in fuel and power as a result of the reduction in moisture to be removed in the plant. Thus, if the opinions of many grape dehydrators and the conclusions from these experiments are correct,

namely, that exposure before dehydration results in improvement in color, it may be seen that this improvement is obtainable without appreciably affecting the cost.

The costs of sun drying raisins are variously estimated[1, 2, 7] at from $12 to $31.50 per dry ton. If $20 per ton is taken as an average figure, it will be seen that the cost of dehydration averages about $15 per ton or ¾ cent per pound more.

In view of the gain in yield possible by deferred picking, the freedom from risk of rain damage, and the fact that the dehydrated Golden Bleached Thompson brings a premium in price, the additional cost of dehydration appears to be much more than offset by the advantages it affords. It is necessary to realize, however, that as yet the market for this special product is limited, and too rapid increases in production are inadvisable.

CONCLUSIONS

1. The dehydration of grapes in California is largely limited to the production of a new type of raisin, the "Golden Bleached" Thompson.

2. Dehydration of seedless grapes can be recommended, although the demand for the product is at present limited. The grapes should be dipped before dehydrating and may be sulfured if desired.

3. The dehydration of natural seedless and Muscat raisins is recommended only for the prevention of rain damage or the salvage of fruit already slightly damaged.

4. Dehydration of wine or juice grapes and of table grapes is not recommended at present, for lack of a market.

5. Dehydration offers improvement in quality and yield by making it safe to defer picking until full maturity is reached.

6. For highest efficiency in dehydration the grapes must be dipped.

7. Special dips containing olive oil, glycerin, or mineral oil offer possibilities for improvement of color and keeping quality.

8. Dehydraters suitable for prunes if sufficiently flexible give satisfactory results in grape drying. The requirements for heat and air supply are greater for grapes than for prunes.

9. Finishing temperatures not exceeding 165° F are safe for the dehydration of dipped Thompson grapes.

10. The relative humidity at the finishing temperature should be about 25 per cent. Lower humidities tend to increase costs and impair uniformity of the color of the product, while higher humidities tend to decrease capacity and render the product dark and sticky.

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